

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

CLAIMS LISTING (all of presented claims 1-40)

Claim 1 (Previously Presented): A method for reducing micromasking residue remaining within an exposed interface region of an oxide-based hardmask layer and an underlying metal-containing anti-reflection coating layer (ARC layer) after the hardmask layer has been patterned, where the residue includes nodules containing one or more oxides and each having a base anchor portion and an upper body portion, the method comprising:

- (a) providing a chemically reactive, first agent which will react with a first metal element of the metal-containing ARC layer to produce a volatile byproduct, the first agent being sufficiently small in size to operatively enter reaction zones of the base anchor portions of at least some of the residue nodules so as to react with the first metal element, if any, in the respective base anchor portions; and
- (b) subjecting the residue nodules to a plasma including said chemically reactive, first agent.

Claim 2 (Original): The residue reducing method of Claim 1 wherein

- (a.1) said chemically reactive, first agent is selected from the group consisting of: chlorine and HCl.

Claim 3 (Currently Amended): ~~The residue reducing method of Claim 1~~

A method for reducing micromasking residue remaining within an exposed interface region of an oxide-based hardmask layer and an underlying metal-containing anti-reflection coating layer (ARC layer) after the hardmask layer has been patterned, where the residue includes nodules containing one or more oxides and each having a base anchor portion and an upper body portion, the method comprising:

- (a) providing a chemically reactive, first agent which will react with a first metal element of the metal-containing ARC layer to produce a volatile byproduct, the

first agent being sufficiently small in size to operatively enter reaction zones of the base anchor portions of at least some of the residue nodules so as to react with the first metal element, if any, in the respective base anchor portions; and

(b) subjecting the residue nodules to a plasma including said chemically reactive, first agent; wherein

(a.1) said chemically reactive, first agent is selected from the group consisting of: Cl₂, HCl and BCl₃.

Claim 4 (Currently Amended): The residue reducing method of Claim 3 -1 wherein

(a.1) said first metal element is titanium.

Claim 5 (Currently Amended): The residue reducing method of Claim 3 -1 wherein

(a.1) said oxide-based hardmask layer includes Plasma-Enhanced Tetra-Ethyl-OrthoSilicate (PE-TEOS).

Claim 6 (Original): The residue reducing method of Claim 5 wherein

(a.2) said interface region is defined by the PE-TEOS material contacting the metal-containing ARC layer.

Claim 7 (Previously Presented): The residue reducing method of Claim 1 wherein

(b.1) in addition to said chemically reactive, first agent said subjecting step subjects the residue nodules to a plasma further including one or more additional chemically reactive agents which can react with, and volatize materials present in the base anchor portions of the residue nodules.

Claim 8 (Previously Presented): The residue reducing method of Claim 1 and further comprising:

(c) providing a relatively, chemically nonreactive, second agent which does not substantially react with the first metal element of the metal-containing ARC layer to produce a volatile byproduct, the second agent being sufficiently large in average mass for physical bombardment purposes to operatively weaken attachments of the base anchor portions of the residue nodules to the interface region so as to thereby encourage break away and removal of the residue nodules from the interface region; and

(b.1) wherein in addition to said chemically reactive, first agent said subjecting step subjects the residue nodules to a plasma including said second agent.

Claim 9 (Original): The residue reducing method of Claim 8 wherein

(a.1) said second agent is selected from the group consisting of: argon, helium, neon, krypton and nitrogen.

Claim 10 (Original): The residue reducing method of Claim 8 wherein

(b.2) said subjecting step includes establishing a first inflow rate for the first agent in the range of about 10 sccm to about 50 sccm.

Claim 11 (Original): The residue reducing method of Claim 10 wherein

(b.3) said subjecting step includes establishing a second inflow rate for the second agent in the range of about 50 sccm to about 150 sccm.

MacPherson Kwok Chen & Heid
LLP
1762 Technology Drive,
Suite 226
San Jose, CA 95110
Telephone: (408) 392-9250
Facsimile: (408) 392-9262

Claim 12 (Original): The residue reducing method of Claim 11 wherein

(b.2a) said subjecting step includes establishing the first inflow rate for the first agent in the range of about 15 sccm to about 25 sccm; and

(b.3a) said subjecting step includes establishing the second inflow rate for the second agent in the range of about 70 sccm to about 90 sccm.

Claim 13 (Original): The residue reducing method of Claim 11 wherein

(b.2b) said first agent is chlorine; and

(b.3b) said second agent is argon.

Claim 14 (Original): The residue reducing method of Claim 8 wherein

(b.2) said subjecting step includes establishing a plasma pressure range of about 2mT to about 15mT.

Claim 15 (Original): The residue reducing method of Claim 14 wherein

(b.2) said subjecting step includes establishing a plasma pressure range of about 6mT to about 12mT.

Claim 16 (Original): The residue reducing method of Claim 8 wherein

(b.2) said subjecting step includes establishing a plasma power in the range of about 300 watts to about 600 watts.

Claim 17 (Original): The residue reducing method of Claim 16 wherein

(b.2a) said subjecting step includes establishing for a chamber supporting said plasma, a pedestal bias power in the range of about 80 watts to about 200 watts.

Claim 18 (Original): The residue reducing method of Claim 8 wherein
(b.2) said subjecting step includes maintaining said plasma having said first
and second agents for an effective residue reducing time of about 3 seconds to about
20 seconds.

Claims 19-23: (Canceled).

Claim 24 (Previously Presented): A method for preventing or reducing formation of
micromasking residue in an interface zone between a metal-containing anti-reflection
coating layer (ARC layer) and an overlying oxygen-containing hardmask layer,
where said residue can otherwise be microscopically observed after the hardmask
layer has been patterned, said method of preventing or reducing comprising:

(a) interposing an oxygen-poor interfacial layer into the interface zone,
between the metal-containing ARC layer and the oxygen-containing hardmask layer.

Claim 25 (Original): The residue reducing method of Claim 24 wherein:

(a.1) said ARC layer contains substantial amounts of titanium;
(a.2) said hardmask layer contains PE-TEOS; and
(a.3) said oxygen-poor interfacial layer is composed of $\text{Si}_x\text{O}_y\text{N}_z$, where $x>0$,
 $z>0$ and where the density of oxygen in said oxygen-poor interfacial layer is less than
the density of oxygen within the PE-TEOS of the adjacent layer hardmask layer.

Claim 26 (Previously Presented): The residue reducing method of Claim 24 wherein:

(a.1a) a calculated ratio of y to x is substantially less than 2 to 1.

MacPherson Kwok Chen & Heid
LLP
1762 Technology Drive,
Suite 226
San Jose, CA 95110
Telephone: (408) 392-9250
Facsimile: (408) 392-9262

Claim 27 (Original): The residue reducing method of Claim 8 wherein a volumetric inflow ratio is established for respective inflow of the chemically reactive, first agent relative to inflow of the chemically nonreactive, second agent and said volumetric inflow ratio is in the range of about 1-to-10 (1:10) to about 4-to-10 (4:10).

Claim 28 (Original): The residue reducing method of Claim 27 wherein said volumetric inflow ratio is in the range of about 2:10 to about 3:10.

Claim 29 (Original): The residue reducing method of Claim 28 wherein said volumetric inflow ratio is about 1:4 (25%).

Claim 30 (Original): The residue reducing method of Claim 29 wherein said chemically reactive, first agent includes chlorine and said chemically nonreactive, second agent includes argon.

Claim 31 (Previously Presented): The residue reducing method of Claim 1 wherein said nodules form as clumps of residue material having an average diameter of about 100Å.

Claim 32 (Previously Presented): The residue reducing method of Claim 1 wherein said nodules form as clumps of residue material having a maximum diameter of about 500Å each.

Claim 33 (Previously Presented): The residue reducing method of Claim 1 wherein said nodules contain one or more oxides of titanium.

Claim 34 (Previously Presented): The residue reducing method of Claim 33 wherein said nodules contain fluorides of titanium.

Claim 35 (Previously Presented): A method for reducing micromasking residue remaining within an exposed interface region of an oxide-based hardmask layer and an underlying metal-containing anti-reflection coating layer (ARC layer) after the hardmask layer has been patterned with use of UV photolithography, where the residue includes nodules containing one or more oxides and each having a base anchor portion and an upper body portion, the method comprising:

(a) providing a chemically reactive, first agent which will react with a first metal element of the metal-containing ARC layer to produce a volatile byproduct, the first agent being sufficiently small in size to operatively enter reaction zones of the base anchor portions of at least some of the residue nodules so as to react with the first metal element in the respective base anchor portions of the at least some nodules;

(b') providing a relatively, chemically nonreactive, second agent which does not substantially react with the first metal element of the metal-containing ARC layer to produce a volatile byproduct, the second agent being sufficiently large in average mass for physical bombardment purposes at operative energies to operatively weaken attachments of the base anchor portions of the residue nodules to the interface region so as to thereby encourage break away and removal of the residue nodules from the interface region; and

(c') subjecting the residue nodules to a plasma including said chemically reactive, first agent and said chemically nonreactive, second agent, where the plasma physically bombards the upper body portions of the nodules with said second agent at said operative energies while chemically attacking the base anchor portions of the nodules with said first agent so as to thereby dislodge the nodules.

Claim 36 (Previously Presented): The method of Claim 35 where the first agent includes chlorine molecules.

MacPherson Kwok Chen & Heid
LLP
1762 Technology Drive,
Suite 226
San Jose, CA 95110
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Claim 37 (Previously Presented): The method of Claim 36 where the second agent includes argon.

Claim 38 (Previously Presented): A residue removing method used between a fluorine-based dry etch of an oxygen-containing hardmask and a chlorine-based dry etch of a metal-containing anti-reflection coating layer (ARC layer) that directly underlies the hardmask, where the residue that is to be removed includes one or more oxides of said metal contained in the ARC layer, the removing method comprising:

subjecting the residue to a plasma that physically bombards top portions of the residue with nonreactive bombardment particles while simultaneously attacking base portions of the residue with chemically reactive particles that convert said metal into volatile byproducts.

Claim 39 (Previously Presented): The method of Claim 38 where the nonreactive bombardment particles of the plasma include argon particles.

Claim 40 (Previously Presented): The method of Claim 39 where the chemically reactive particles of the plasma include chlorine particles.
